

Lecture Module - Sensors

ME3023 - Measurements in Mechanical Systems

Mechanical Engineering
Tennessee Technological University

Module 4 - Sensors

Module 4 - Sensors

- Topic 1 - Introduction and Overview
- Topic 2 - IC and MEMS based Sensors

Topic 1 - Introduction and Overview

- Classification of Sensors
- Analog and Digital Sensors
- Example 1: Distance or Range
- Example 2: Rotation

Classification of Sensors

a **sensor**, a physical element that employs some natural phenomenon... ..to sense the variable being measured

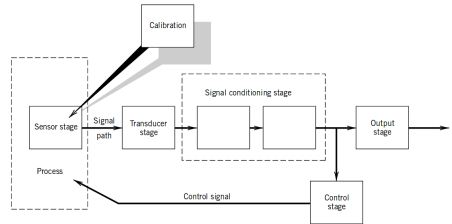
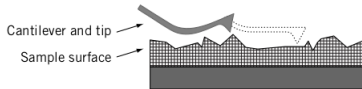


Figure 1.5 Components of a general measurement system.

Classification of Sensors

Analog and Digital Sensors

Sensors are typically classified as either **analog** or **digital** based on the type of signal that is output from the sensor.

Analog	Digital	Both?
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However, this can be a misleading term. Many digital sensors operate based on analog circuit principles but require a digital circuit or MCU to operate or communicate.

Analog and Digital Sensors

Other Classifications:

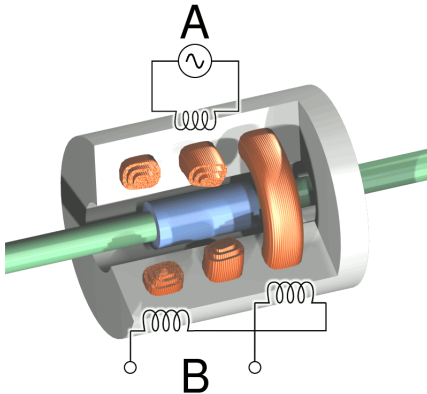
- Contact vs Non-Contact
- Programmable (Configurable) vs Non-Programmable
- By Measured Variable

Analog and Digital Sensors

Example 1: Distance or Range

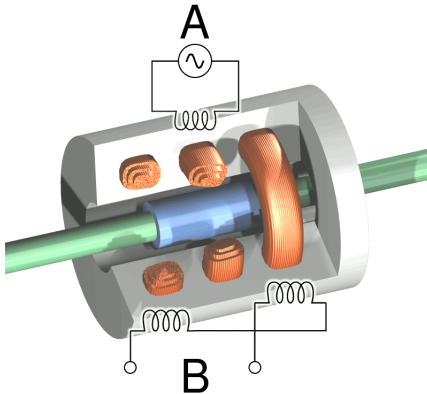
Thought Exercise: How do we measure distance (aka range)?

Example 1: Distance or Range



LVDTs with NI
LVDT Animation

Example 1: Distance or Range



Example 2: Rotation

Thought Exercise: How do we measure **rotation**?

- What variable or quantity is used to describe **rotation**?
 -
 -
 -
- What type of sensor is used to measure this?
 -
 -
 -

Example 2: Rotation

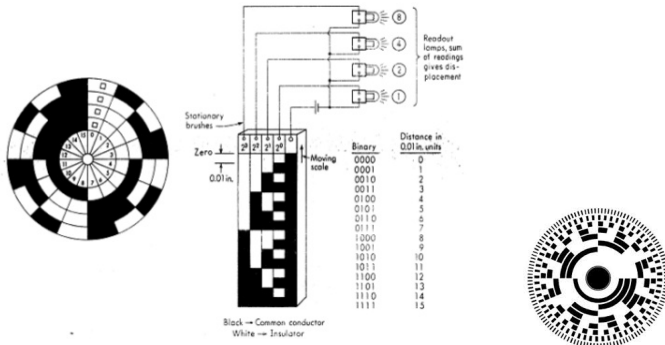
Rotational Potentiometer



Example 2: Rotation

Absolute Encoder

4-Bit Binary Optical Absolute Encoder Disk

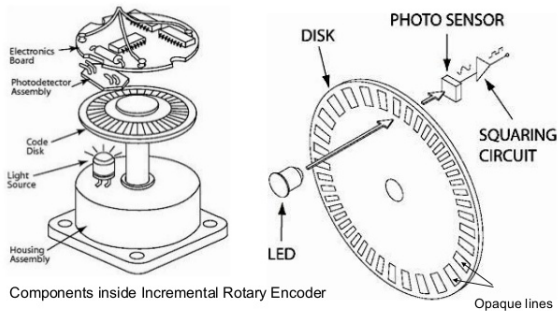


Example 2: Rotation

Incremental Encoder

2. Types of Rotary Encoder - Incremental

Construction of Incremental Rotary Encoder



Components inside Incremental Rotary Encoder

Example 2: Rotation

- What applications require this type of sensor?



Example 2: Rotation

- How does this type of sensor work?



Example 2: Orientation

Thought Exercise: How do we measure **orientation**?

- What variable or quantity is used to describe **orientation**?
 -
 -
 -
- What type of sensor is used to measure this?
 -
 -
 -

Example 2: Orientation

- What applications require this type of sensor?



Example 2: Orientation

- How does this type of sensor work?



Topic 2 - IC and MEMS based Sensors

- Integrated Circuits
- Micro Electro-Mechanical Devices
- Example 1: Magnetometer and Digital Compass
- Example 2: Accelerometer

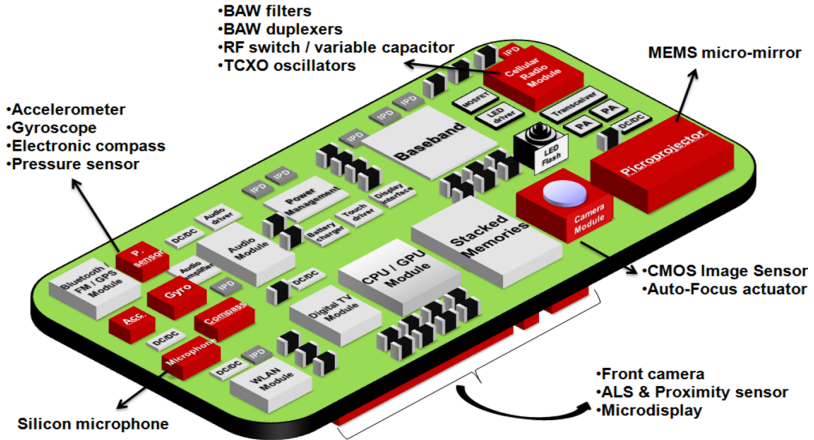
Integrated Circuits

Activity: Group Brainstorming

List three applications or devices that use IC based sensors.

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-
-

Integrated Circuits



Micro Electro-Mechanical Devices



Activity: Group Brainstorming List three sensors that are found on a high performance quadcopter or drone.

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-
-

Micro Electro-Mechanical Devices

Example 1: Magnetometer and Digital Compass

An accelerometer is a tool that measures proper acceleration, which is the acceleration of a body in its own instantaneous frame.

Applications:

- Navigation Systems - Robotics - Aircraft - Missiles
- Personal Devices - Phones - Tablets
- Others:

Example 1: Magnetometer and Digital Compass

Thought Exercise: How do we measure acceleration?

Activity: Group Brainstorming

Explain one method for measuring acceleration of a body.

Example 1: Magnetometer and Digital Compass

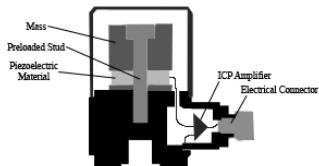
Mechanical Accelerometers Consist of a damped mass spring system and a sensing device.

Types of accelerometers:

- Seismometer or Seismograph
- piezoelectric - charge in material resulting from mechanical stress
- piezoresistive - change in resistance resulting from mechanical stress
- capacitive

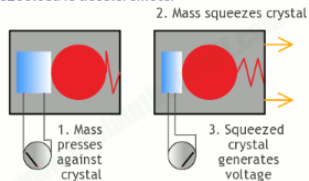
Example 1: Magnetometer and Digital Compass

piezoelectric accelerometer



Piezoelectric accelerometer

www.explainthatstuff.com

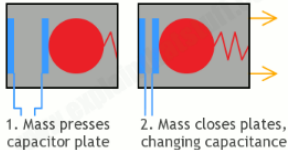


Example 1: Magnetometer and Digital Compass

capacitive accelerometer

Capacitive accelerometer

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Example 2: Accelerometer

Thought Exercise: How do we measure **orientation**?

- What variable or quantity is used to describe motion?
 -
 -
 -
- What type of sensor is used to measure this?
 -
 -
 -

Example 2: Accelerometer

- What applications require this type of sensor?



Example 2: Accelerometer